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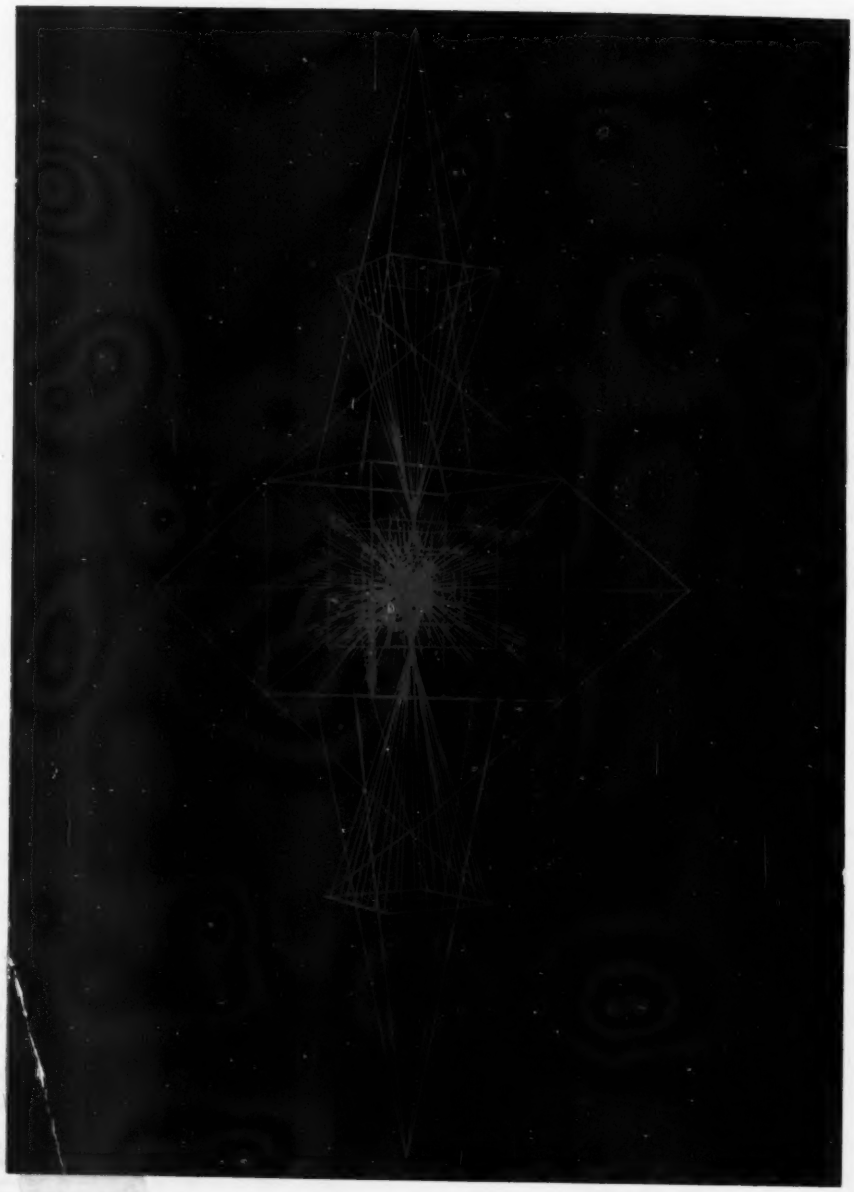

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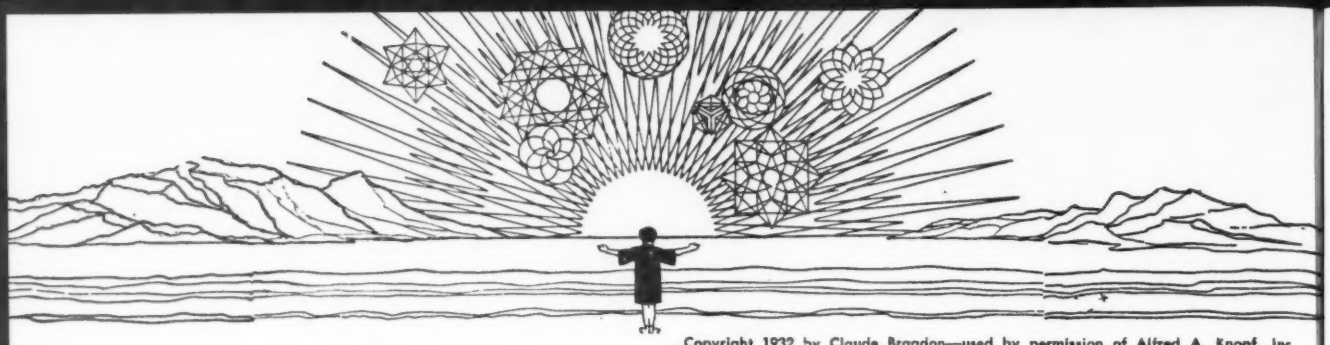

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MAIN CURRENTS
IN MODERN THOUGHT

A cooperative journal to promote the free association of those working toward the integration of all knowledge through the study of the whole of things, Nature, Man, and Society, assuming the universe to be one, dependable, intelligible, harmonious.

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THE NEW DIMENSIONS OF MAN*

Donald Hatch Andrews

The Hyper-Form

Boundaries of the Human Spirit

DOWN through the centuries from the very beginnings of human thought, there has been a continuing search for the answer to the question: "What are the dimensions of man?" Sometimes the question is confronted explicitly as in Reinhold Niebuhr's great essay on *The Nature and Destiny of Man.* He says, "Man's dimensions include both time and eternity. But eternity is neither infinite time nor undifferentiated unity." Frequently, the question is present implicity, as in the legend of Petrouchka, the Russian Pierrot. In one version, Petrouchka is a puppet of human size, made from clothes stuffed with sawdust and displayed in a sideshow at country carnivals by a showman who is a magician and who has mysteriously endowed the puppet with a kind of life. Petrouchka has two companions, similarly made and also magically alive, a ballerina and a blackamoor, and as they go from carnival to carnival, the sparks of life in the puppets kindle, and they acquire human emotions. Thus both Petrouchka and the blackamoor fall in love with the ballerina, who flirts with each but finally repulses Petrouchka and embraces his rival. Brooding over this, Petrouchka suddenly, in the midst of the show, attacks his rival, but the blackamoor seizes his scimitar, chases Petrouchka off the stage into the marketplace, and slays him. When the spectators are startled at the realism of the fight, the showman displays the sawdust limbs, so that they are reassured and leave laughing. Then, as darkness follows and the snow begins to fall, the showman trudges off trailing the limp puppet, but he is suddenly frozen with terror as the ghost of Petrouchka appears against the sky, embodied in an unearthly light, violent and threatening.

In our own time, this legend has had a remarkable revival in a ballet produced by Diaghilev, with music by Igor Stravinsky, one of the series created by these collaborators which produced such a revitalizing effect on the ballet theater in the early part of this century. Nijinsky was the first interpreter of the role of Petrouchka, and it is said that those who saw him felt a peculiar fusion of his life into the role. For it was his last and perhaps his greatest interpretation, and he departed from it to enter a mental hospital for a long confinement, which ended in death.

In many ways, the most moving scene in this ballet is in the second act, where the puppet Petrouchka is found imprisoned alone inside the walls of the great packing case in which he is carried from city to city. As the curtain rises, the music suggests his longing for freedom and the turmoil of his emotions heightened by confinement, while the gigantic image of his creator and captor, the magician, glares down at him mockingly from the back wall of the box. In a frenzy, Petrouchka dashes back and forth, banging his head and his whole body against these walls. We sense that Petrouchka is humanity. Is man, then, nothing but a puppet dancing to the mocking tune of a magician? As the twentieth century physicist might put it, is man nothing but a particle in a box? *Or,* as Niebuhr expresses it, do man's dimensions extend beyond the boundary walls of the finite to include both time and eternity? And can we somehow achieve a sense of that eternity while confined here in time? Can we transcend our finitude?

It is in this perspective that reflections on Petrouchka's box and the particle in the box of the modern physicist open new vistas. For our views on the fundamental particles of nature have undergone profound changes within the last three decades; and since we, along with the rest of the universe, are made of these particles, these new discoveries change the perspective in which we must view ourselves. Forty years ago, the fundamental building blocks of the universe, the electron, the proton and the heavier atomic nuclei, appeared to be *particles of matter;* they obeyed the laws of mechanics; their aggregates constituted machines. This led many scientists and philosophers to conclude that human beings are merely machines and that the universe is a vast supermachine, gears interlocked with gears, grinding on in inexorable determination from an initial to a final infinity of time. But because of a series of startling new concepts, stemming from a suggestion by the French physicist, Louis de Broglie, about 1925, and confirmed in a variety of ways experimentally, it now appears that the behavior of these fundamental en-

*Preliminary draft of an address given at the Colloquium on The Nature of Man, Boston, Mass., May 23, 1959.

tities is characterized less by a particle-like and more by a wave-like nature; and it is the harmonic relations of these waves which determine the aspect and action of all that the universe contains. In a word, both the universe as a whole and we in particular are not matter but music; so here we have a new perspective in which we see something very different from deterministic behavior. Here, there begins to emerge evidence for new dimensions of man. From the spectroscope and the telescope, from deflection and refraction, we are obtaining signs and portents compelling us to reorient our sights nearer to the directions scanned by saints and seers in the many centuries past.

Now you may be disturbed that we are seeing these new vistas through the eyes of instruments rather than through inner vision. But as Alfred North Whitehead remarked, the doubt implied in the question, "Canst thou by searching find out God?" is good Hebrew but bad Greek. On the one hand, it can be argued that Satan fell because of an indecent desire to understand his Creator, and there may be some who feel that Satan was the first scientist and they suspect that today's physicists, chemists and biologists are his offspring. They say that what appears to be scientific proof today may be close to falsehood tomorrow and that to erect a temple of faith on these shifting sands is worse than folly. I agree with them completely that evidence from the laboratory should not be the primary basis of faith. On the other hand, it cannot be denied that today when science speaks, many listen. Rightly or wrongly, because of its impressive material accomplishments, science has acquired great authority especially in the minds of the younger generation. For this reason, I believe that it is important to try to see as clearly and completely as we can the deeper implications in this new perspective which results from the changing interpretation of the nature of the fundamental entities of the universe and the way in which they interact.

The Atom As Machine

TO bring out more vividly the nature of this change, I would like to review briefly the concept of the atom as a machine and then compare this with the new concept of the atom as music. Inevitably, when we speak of atoms, we deal with small dimensions and large numbers. The atom is almost inconceivably small and the number of atoms even in the human body is almost unimaginably large. In order to get some feeling for these large numbers, I once calculated the volume occupied by octillion peas, there being about octillion atoms in the human body. First, I counted out a hundred peas and found that they occupied a volume of about one cubic inch. Thus, a million peas would fill a household refrigerator, a billion peas would fill a whole house, a trillion peas would fill the houses in a medium-sized town, and a quadrillion peas would fill all the buildings in the city of Boston. Since buildings quickly become inadequate as we go up the scale adding three ciphers at a time, I decided to take the state of Pennsylvania as my measure. Imagine a blizzard over Pennsylvania, but instead of snowing snow it snows peas. We get a blanket of peas, four feet deep, covering Pennsylvania, all the way from the Maryland line up to New York state and from New Jersey out to Ohio. With the state thus covered, we will have approximately quintillion peas. The blizzard then rages over all the land areas of the globe and when we have North America, South America, Europe, Asia and Africa covered with peas four feet deep, we have sextillion. Next, we freeze over the oceans, cover the entire surface of the globe with our blanket of peas, go out into the Milky Way, get 250 other planets about the size of the earth and cover those also, and then we have septillion. Finally, we go out into the farthest reaches of the galaxy, assemble 250,000 planets, each the size of the earth, cover all these with peas four feet deep, and then, at last, we have octillion peas equal in number to the aggregate of atoms in an average human body. Thus, we can grasp a little of the smallness of the atom and the enormity of our own complexity.

We now wish to look inside one of these small atoms. Suppose we pick for our specimen an atom of calcium in the tip of the bone of your fore-finger. Imagine that you can take an Alice-in-Wonderland growing pill and enlarge your body by a factor of a trillion, at the same time enlarging this atom of calcium. You will attain a length of over 100 million miles, the order of the radius of the earth's orbit around the sun, and this atom of calcium will grow to a great ball about 100 yards across, big enough to put a football field inside.

If we step inside this enlarged atom and put on magic glasses which give us the older *particle* view of things, we will see circulating over our heads, down at the sides and under our feet, some twenty balls, perhaps roughly the size of footballs. These are the electrons, the particles of negative electricity which circulate like plants around the sun and by their motions create the forces which bind this atom to its neighbors, thus making up the solid structure of the fingerbone. We look down at the center to see if there is an atomic sun holding these planetary electrons in their courses and there, with the atom 100 yards across, we see a tiny whirling point the size of a small marble. This is the atomic nucleus, the speck which contains almost the entire mass of the atom and its charge of positive electricity. We ask what else there is and the answer is nothing, nothing but empty space. And since we are made of atoms we are nothing much but empty space, too. If by some magic a superman could take your body in his hands and squeeze these atomic holes out of you the way you squeeze the holes out of a sponge, you would get smaller and smaller until finally, when the last hole was gone, you would be about the size of the smallest speck of dust which you could see resting on this piece of paper. This is a measure of how insubstantial you are.

It was essentially this picture of atoms as whirling

particles which fortified many of the arguments for a mechanistic universe. In almost every way, internally and externally, the atom appeared to obey the laws of mechanics. The failure of its moving electrons continuously to emit radiation was puzzling; but it was pretty much agreed that nevertheless cause generated effect and effect followed cause in an inexorable chain. We, as well as the entire universe, appeared to be nothing but gears grinding in gears. As Lucretius put it: one breath of lavish creation, then one iron law of change; this is the true echo of the life of matter. Moreover, this life of matter appeared to embody other laws which boxed in the possibilities for the universe. The law of conservation of matter asserted that matter could neither be created or destroyed. A similar law of conservation asserted that the same relation applied to energy, the dynamic factor which makes the world go around. True, the theory of relativity showed the possibility of changing matter into energy or vice versa, and this gave us one box instead of two, but we were still left inside the box. Finally, the second law of thermodynamics asserted that this energy was tending more and more toward uniform distribution over all possibilities and that, consequently, the universe was running down. As Norbert Weiner expressed it, the universe tends toward democracy, and when it has achieved that state it will be incapable of doing anything more.

As we look back with hindsight on the work and thoughts of many of these scientists and the scientifically minded philosophers prior to 1900, we thus become more keenly aware of the structure of their thought, both their knowledge and their ignorance, conscious and unconscious; and we cannot blame them too much for some of their hasty conclusions. After all, mechanics and thermodynamics produced the steam engine with its revolutionary effect on world economy; and in dozens of other ways science enabled man to do things, new in kind and vastly expanded in scale. Mechanics was the foundation of this great edifice of applied power and it certainly was tempting to argue that eventually every aspect of the universe could be explained in terms of mechanics. But just as this picture of the machine-universe appeared to be approaching perfection at the turn of the century, there came suddenly the remarkable series of discoveries including evidence for the break-up of the atom, the particle nature of light, curved space, and the interconversion of energy and matter. The culmination of this revolution was the proof of the wave-nature of matter complementary to the discovery of the particle nature of light.

The Atom As Music

IN order to see pictorially the meaning of this new perspective, let us go back inside your atom of calcium which we observed earlier through the spectacles of classical physics, now putting on the more penetrating spectacles of the new quantum mechanics and equipping ourselves with a magic superhearing-aid. As thus equipped we step inside your atom which is 100 yards across, we no longer see the circulating particles but find the atom filled with waves and ripples, something like the ripples which we see on the surface of a pond when a stone is dropped in it. Occasionally, these waves pile up at points and there emerges something which looks like one of the particles in our earlier picture; but we get a new awareness that the behavior of the atom and its component electrons is much more clearly to be seen in these waves than in the motion of particles. Next we turn up our hearing aid and we perceive music. Some of this has familiar harmony, like the major and minor triads to be heard in the concert hall. But much of it is unfamiliar, full of relationships which, to be expressed mathematically, must contain very large numbers or even some of the irrational numbers not to be found in our familiar integral set of 1, 2, 3 and so on. Also, nearly all of it is dozens of octaves above the truly audible range of the human ear.

These electron waves which we thus "hear" are neither sound waves nor light waves; and many scientists feel that they are not strictly physically *real*. This, of course, raises the question of what we mean by "real," the question which has been explored in such a penetrating way by Henry Margenau and other physicists and philosophers who are keenly aware of the importance of clarifying the structure of our thought in this area. For our purposes, it is sufficient to point out that the electrons and all other fundamental entities behave *as if* these waves are there. And it is hard to find any better basis for asserting reality than a pattern of behavior. So I think that Pythagoras with his vision of the universe as music or waves deserves as much credit as Democritus with his vision of the particulate or atomic aspect of matter.

Passing over for the time being the question of the reality of these de Broglie waves, let us examine in more detail the nature of the relationships which suggest the wave theory. One of the more familiar examples of one-dimensional wave motion is found in a piano string, say, middle C. When plucked, this string vibrates first of all with its fundamental tone of 256 cycles per second; the ends of the string remain motionless, fixed to the framework of the piano while the part of the string in between bows up and down, the maximum amplitude being at the middle of the string. But if we observe carefully, we also see that there is another kind of wave present with two bows. For example, the left half of the string may bow up while the right bows down, and in this type of vibration the string sounds a note one octave above the fundamental at 512 cycles per second. As we observe still more carefully, we see types of motion with three bows, four bows, five bows and so on, sounding notes corresponding to G, a higher C, and E and the higher *harmonics*. But we never observe a *fraction* of a bow because this would necessitate the movement of the end of the string, and this is impossible because the end of the string is fixed at its pin to the piano framework and cannot move. Thus the *bound-*

ary condition of the *fixed ends* of the string forces our string to vibrate only with an integral number of bows. Thus, the modes and values of vibration of the string are determined both by the boundary conditions and by the weight and tension of the string. In the case of the string, we normally hear the simple harmonic overtones corresponding to some of the low integral numbers.

Now let us consider a two-dimensional wave pattern as found on the head of a drum; here, when the drum is struck, we get more complicated modes of vibration corresponding to ratios of larger numbers and even fractions. This is because the *boundary* condition around the *fixed rim* of the drum is very different from that imposed by the fixed ends of the string. We even get one set of vibrations for a round drum head and another for a square drum head, an infinite variety of vibration patterns for an infinite variety of head shapes! When we go to the three-dimensional case, a vibrating solid, we get even more various and complicated patterns of vibration. Thus a sphere vibrates with one pattern, an ellipsoid with another, a cube with a third. Even a statue like Venus de Milo has a set of vibrations or a harmony, the form in music which expresses the form in space.

Now the atom behaves much like the vibrating three-dimensional statue. Speaking now in a very general sense, the internal tensions and the boundary conditions make possible only certain definite vibration patterns. This means that the atom can exist only in certain *energy states*. In these energy states, the "frequency" of the vibration of the de Broglie wave takes on certain values only, and these may be said to be the tones which we "hear" with our magic hearing aid. The invisible walls of its boundary "box" determine the song of the electron as the walls of Petrouchka's box determine his dance. But while the use of wave mathematics for investigating the behavior of the atom is very helpful, it is possible to use other mathematical approaches as Heisenberg originally pointed out; thus mathematical matrices also provide a representation for these forms. So we conclude that the ultimate reality of the atom lies close to pure mathematical dynamic form. So proceeding on our journey of exploration we find ourselves,

"In die schoenen regionen
Wo die reinen formen wohnen."

Because music is in reality also pure dynamic form, I think that it is both suggestive and meaningful to say that the atom now appears to be music.

The Importance of Boundaries

LET us now contrast certain aspects of these two points of view, the atom as machine and as music. First of all, the particle picture implies *discontinuous* matter with *continuous* forces acting in *continuous* space. Now the primitive idea of *discontinuous* matter goes back to the early Greek philosophers who appreciated the difficulty of explaining the variety of the universe in terms of continuity; yet accepting this idea, it seemed reasonable to their successors to assign continuity to space and time and to the forces like gravity and electrical attraction which act in space and time. So in classical physics we had a picture of discontinuous matter and continuous action contained in a continuous cartesian space with the three dimensions of length, breadth and height (x, y, and z) all at right angles to each other. It was a simple universe with everything on the square. And time was regarded as equally simple in nature, flowing on continuously.

Now in looking at the way matter behaves, there are two important aspects, the core and the boundary. You can hold in your hand a piece of matter and concentrate on it and on the space immediately surrounding it; this is the core. Or, you can turn and look away to the boundary of the surroundings. And, if you look away, how far can you look and what do you see out at the edge of the horizon? These are the two perspectives, the core and the boundary; and the developments in many different parts of scientific thinking within the last century have emphasized more and more the fact that both are equally important. Moreover, there are both outer and inner boundaries.

In probing the nature of the space in which atoms act, the outer boundary comes to mind at once. Does space go on and on forever? Is space infinite? Classical physics answered *yes;* and this appeared to be a complete and satisfying answer to most minds trained in the thought patterns of western civilization developed over the last half dozen centuries. But to us today, this appears to be a lazy answer. When loosely used, infinity is a word which implies a kind of repetitive process of thought with all the somnolent satisfaction that goes with repetition. We start out in space and we go on and on and on and on, and we jump to the conclusion that we can go on and on forever. But this concept of infinity is far from clear, if indeed it has any real meaning. It is therefore, striking that the theory of relativity points to a more significant kind of boundary to space, the finite hyper-sphere in four dimensions.

With regard to *matter,* the Greeks clearly saw that there was also a question of an inner boundary. Can matter be divided and redivided, and redivided indefinitely? They felt that here the answer was *no.* This hypothesis has been strikingly confirmed, of course, by all our evidence from modern atomic theory. Thus, we can take a piece of marble a foot-square and break it up into smaller and smaller fragments, and each piece is still marble. Each piece still has both the physical and chemical properties of marble. Chemically speaking, it still has the same formula as the original piece of marble, namely, calcium carbonate. These properties are still retained as the pieces are subdivided further until we get to fragments a few hundred millionths of a centimeter in diameter; for this is the size of a single *unit* of calcium carbonate, one calcium atom, one carbon atom and three oxygen atoms. If we divide further, we will find that one fragment is a calcium atom or another is an oxygen atom, either piece having completely different properties

from the original marble. If we cut these atoms up, we get electrons and nuclei; and if we cut the nuclei up we get protons and neutrons; and the free neutrons spontaneously break up to give other protons and electrons. At this point, the concept of *cutting up* becomes meaningless. In other words, as we approach this inner boundary of matter, the whole fabric of law and relationship as well as the nature of the things related becomes different in kind. The concept of space itself on this small scale becomes meaningless. Thus, we get a clarified concept of *boundary* from the consideration of this *inner* boundary as we go to small dimensions. Matter is not continuous; it is not infinitely divisible; the inner boundary of matter is *not* infinitely remote.

Similar considerations apply to time. Here, because of the vectorial or directional quality of time, it is natural to consider first of all two outer boundaries. If we look backward in time, do we look backward infinitely far? Classical physics answered *yes*. If we look forward in time, do we again look forward without limit? Classical physics, likewise, answers yes. Is there an inner boundary to time similar to the inner boundary of the nature of the matter at small dimensions? No one knows. Later we will explore further the boundaries of time, because it is only through the study of matter in action that we can dissect time, and the existence of an inner boundary of matter does suggest an inner boundary of time.

Let us now consider other ways in which these new approaches change our fundamental scientific thinking. One of the most striking is concerned with the question whether "the whole is equal to the sum of the parts" or "the whole is more than the sum of the parts." In the mechanistic description of the atom, the situation is best expressed by the first statement. If we understand exactly the nature of the gears and pinions and other mechanical parts of a watch, it is fair to say that we understand how these parts will behave when linked together into the whole. The possibilities of behavior of the whole are contained in the possibilities of behavior of the individual parts. But, in the case of waves, at the deeper level of pure form, this is no longer true. Here, the whole is *more* than the sum of the parts. The dynamic aspect of form, the possibilities of "feed-back," of intimate interaction yield this result; and one has to go to a very deep level in the interpretation of the meaning of form to grasp this principle completely. In some of his books on quantum mechanics, Hermann Weyl tries to make this point clear. For example, he says, "In fact every vector in the product space represents a possible wave state. In this very radical sense, quantum physics supports the doctrine that the whole is more than the combination of its parts." Thus, from the mathematical point of view, in trying to grasp the meaning of form and the meaning of *existence* of form, we come to a new perspective. Instead of thinking of a form existing in space, we realize that we have a choice of many different kinds of spaces in which to represent the form and we can even say that a form can create its own space, that form transcends space.

In order to clarify these concepts, let us consider further certain atomic phenomena. When atoms are grouped together, aspects of behavior may be associated with the behavior of the group as a whole but not with the atoms acting separately and individually. There is in the collective behavior something more than is found in the individual part. Frequently, when we try to express this collective behavior in terms of ordinary three-dimensional space and time, we are faced with great difficulties and complexities. On the other hand, if we can think of each atom as having its own private dimensions, we can express the behavior of the collection of atoms in multidimensional space in a way which delineates the pattern of form more significantly. This is true for the description of the collective motions of a group of atoms bound together in the form of a molecule, where the possible motions depend on the geometric and potential force pattern of the group as a whole. It is true for cooperative phenomena such as the conduction of electricity by metals, particularly true for the strange kind of superconductivity which is found at extremely low temperatures within a few degrees of the absolute zero of temperature. To express most elegantly the group behavior of electrons associated with an atom nucleus or with several atomic nuclei, it is frequently necessary to use a space of an infinite number of dimensions. Such spaces originated in the mathematical methods developed for treating functional relationships, and the generic term *Hilbert space* is often used to refer to them, in honor of the mathematician David Hilbert who fathered them. When one sees the need for these more sophisticated approaches in dealing with phenomena associated with the fundamental particles of the universe, one is tempted to ask whether any special kind of space has an exclusive claim to reality. If the totality of relationships points toward multidimensional space as providing the most significant framework for understanding the universe, should we conclude that we actually live in multidimensional rather than three dimensional space? From the common sense point of view, you may say that you yourself are obviously a three-dimensional collection of atoms with certain powers of movement, definitely located at a point in three-dimensional space and time, sitting still at this moment. Well, where are you? I think it is easy to see in this proposition the flavor of what Whitehead calls the deceptive nature of hardheaded clarity. You feel that you are sitting relatively still. But, of course, remember that the earth is turning and that actually you are moving at approximately a thousand miles an hour through space due to the rotation of the earth. The earth is also moving in its orbit around the sun so that this means your path is actually a spiral with respect to the sun. But, of course, the sun is not standing still either. It is a star somewhere near the outer border of our saucer-shaped galaxy which, in turn. is rotating. Our galaxy may be said to resemble

a kind of flying saucer which is spinning in space, and this motion with respect to other galaxies superimposes another component on your spiral around the sun. The galaxy is also moving, we believe, participating in the general movement of the universe which produces the red shift in the light of the farther galaxies. This is a movement in which the galaxies seem to be flying apart from each other at an enormous rate of speed. So your sense of sitting still is very deceptive.

But, you say, "At least, I am concentrated at a particular volume in space. I am not in New York at this moment. I am in Boston." Do not be too sure about that. Consider your relation to the universal force of gravitation. The reason why you are sitting fixed and not floating around in the air is because there is a force acting between each of your atoms and the far more than trillion tons of matrix rock making up the core of the center of the earth. Your atoms project a force field to all these earth atoms, and that isn't all. Your force of gravitation also reaches to the moon, to the sun, and to every other atom in the universe. Because of this, any motion of any one of your atoms moves the rest of the universe. Our understanding of this relationship is still rudimentary but it suggests the truth in the line from Francis Thompson that "thou canst not stir a flower without troubling a star." And not only your gravitational field but also the atom-waves of which you are constituted extend out beyond the apparent boundaries of your body. A little of you is outside this building and you are spread out even beyond that, no one can say exactly how far. Until we understand much more precisely the nature of these interactions, it is impossible to say exactly where you are. So, if there are arguments that collective behavior can be more fully *understood* in multidimensional space, then it is reasonable to ask whether this does not suggest the *existence* of dimensions beyond those of familiar spacetime. I think that this is what Ortega y Gasset was trying to say when he remarked that simple space and time are the stupid aspects of the universe.

There are many other aspects of the new physics which imply the necessity of exploring further our scientific philosophy and its relation to the broader questions of life. There is the curious question of the identity of individual particles associated with the Pauli exclusion principle. There is the Heisenberg indeterminacy principle, which ties more closely the act of observing to the observation. Niels Bohr reminds us that we are both spectators and actors in the drama of existence. So if in our action there is some factor which is more than the sum of the parts, in what space does its reality lie? What are the dimensions of the spirit?

The Dimensions of the Spirit

IN order to explore this area, let us turn first to the aspect of the universe as music which distinguishes it sharply from the machine, namely, the probability aspect. In the light of the Heisenberg indeterminacy principle, we conclude that in this new wave universe action is not completely predictable. It is not determined by the iron law of cause and effect. Where the wave exists there is a probability that something will happen, but it does not inevitably happen. Some physicists feel that this provides the basis for free will in man. They say that our actions are determined by our thoughts, and our thoughts are associated with processes at the atomic level. *Ergo,* if our atomic behavior is not predetermined, we have free will. Others are skeptical and say that when we understand these waves better, we will find the same old law of cause and effect operating between them, and we will be right back in Petrouchka's box of determinism. Still others claim that the very mathematical structure of relationships describing the behavior of these waves excludes the possibility of a deterministic chain. At any rate, determinism has not been re-enthroned as of today and there is nothing as far as I know which suggests that it will be in the future. On the contrary, there are clearly these gaps in the chain of interaction of forces. Someone remarked that it will be unfortunate if we have to find God only in the gaps. But since a chain is as open as its weakest link, this open door in our logic deserves a careful look to see where the path leads through it.

Scanning the phenomenon of human life, one is struck by the fact that in the collective behavior of these octillion body atoms, there is some kind of entity which transcends the changing pattern of the atoms as they come and go in the metabolic process. We know from recent experiments with radioactive tracers that all parts of the body slough off old atoms and take on new ones. It has been stated that we get a new liver every six weeks, though the bones undoubtedly change much more slowly. Sometimes the statement is made that on the average we get a new body every five years. It is too early still to assess the exact speed of these changes in every organ, but it is striking that in parts of the body like the brain we may have a very rapid replacement of atoms through the course of metabolism and yet somehow retain memory and those directive powers which keep the course of life rolling on in coherent fashion. There seems to be an invariance under transformation, a whole which does far transcend the sum of its parts.

Can we be bold enough to say that in view of all these bits of evidence we can speculate on the possibility that we *really exist* in a hyper-Hilbert space, and that this three-dimensional space, which appears to be so obvious around us, is only a rather trivial and shallow shadow? Can we admit the possibility that the human spirit has certain aspects of an invariant vector amid all this vast transformation of atomic coordinates? And granted that there is this transcending of the changes of metabolism, can this spiritual vector transcend the changes of death? If the vibrations of our octillion atoms appear to be like the swarming of an almost infinite army of gnats, is

there a meaning beyond that of continued confusion?

Although we certainly cannot say that the indeterminacy principle proves the freedom of will, still it does look as if the door is open in that direction. Somehow in these dimensions of the spirit, there is a quality that not only transcends the iron law of cause and effect but has within it the spark of creativity and of moral responsibility. Kirkegaard expressed it, "But what is this myself? It is the most abstract and yet at the same time the most concrete of all realities. It is freedom." Stace calls it that spark of God buried in man. If we find an implication in the new physics that this spark transcends space, does it transcend time? This again mathematically speaking appears to be a boundary problem; and we are certainly getting new evidence today concerning the nature of the initial boundary of time. It is still too early to be sure, but one cannot help but be impressed with the evidence that suggests an initial creative event in the universe. For when we extrapolate back in time the motions of the nebulae, it looks as if all the matter of the universe may have been once approximately at one point some five to seven billion years ago; and the rate of radioactive decay of some of the heavier atoms indicates that somehow these nuclear processes all started about five billion years ago. This may be a crude interpretation of the facts but it does indicate that somehow time does not extend back uniformly, that somehow there is a boundary condition on time just as the curvature in relativity suggests a boundary condition on outer space.

Curiously, there appears to be little interest in scientific circles today about the symmetric image of this, the nature of the boundary of time *ahead* of us, but it seems to be a meaningful question to raise. Niebuhr is really stating this boundary problem when he says that the end of time in eternity is not a point in time. Just as the journey into the infinitesimal brings us to a new set of laws and relationships when we get to trillionths of a centimeter, a journey backward in time brings us to new relationships when we go back by something like a quadrillion seconds, and a long journey forward may bring us to an equally strange land. So let us pause for just a moment to think about these relative sizes in time. In one second of time the waves of an electron in a hydrogen atom in the skin at the tip of your finger execute some quadrillion vibrations, more vibrations than there have been seconds of time since this initial boundary which we appear to meet when we go back five billion years. Thus, although five billion years may seem almost infinite in terms of the human lifespan, the ratio of our lifespan to the smallest significant time intervals within us is so great, that relatively, creation took place yesterday and perhaps the conclusion is tomorrow.

We have seen that our conception of the infinite has been largely a conception of ignorance. It even has the flavor of laziness, of repetition beyond repetition beyond repetition, until we can think no farther. Actually, the careful examination of the concept of the infinite by mathematicians within the last 75 years has made it clear the idea has quite another meaning. There are now the three distinct kinds of infinity recognized, the class of integral numbers, the class of all real numbers, and the class of functions or forms, with the latter in a sense being the largest of these three infinities. So far, there has been no significance found for a concept of still larger infinity, though there is nothing to show that it cannot exist. Just as the older concept of infinite space has been altered through relativity and as the concept of infinite time preceding our existence appears to be altering, we can logically ask whether there is not a significance in the ultimate end of time. Somehow the totality of the reality of the universe does seem to transcend both our narrow concept of space, our narrow concept of time and our narrow concept of action. As Santayana put it, spiritual peace will lie in another dimension. I think that Hermann Weyl is pointing in the same direction when he says, "Whether or not the view is tenable, that the organizing power of life establishes correlations between independent individual atomic processes, there is no doubt that wherever thought and the causitive agent of will emerge, especially in man, that power is increasingly controlled by a spiritual world of images." Is it not in order, then, to ask whether this new evidence on the nature of reality does not suggest new dimensions in which to regard man. In our thinking should we not try to break out of the conventional three dimensions of space and the fourth dimension of time when we try to see the meaning of life, physical and spiritual in a unified perspective? I suggest that the evidence points toward a new conceptual framework which will put into focus the forms of the spirit, with dimensions which provide for the creative aspect, the moral freedom of the human soul, a hyper-form space bounded by the infinity of our Creator.

If we can tune our inner ear to hear this music of the universe all around us and within us, perhaps we can learn to discriminate its hyper-harmonies and apprehend the message of its song. I believe that it is a message full of joy and beauty, but also a call to sacrifice and duty.

Today, outerspace is challenging a new Columbus to set forth on an extra-planetary voyage of discovery. Just as truly, these inner spaces of the spirit are calling for a new Kirkegaard and a new Einstein to voyage together on an exploration of their uncharted seas.

Man is not a puppet in a box. The boundaries of man are the mansions of eternity.

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DARWIN AND LAMARCK

H. Graham Cannon

Their Roles in the History of Science as Seen in the Centenary Year 1959

JUST one hundred and fifty years ago Lamarck published his *Philosophie Zoologique,* in which for the first time in the history of science he put forward a reasoned hypothesis to account for the evolution of living things. Its effect on the contemporary scientific world was negligible. Just one hundred years ago Darwin published his *Origin of Species.* The first edition of 1250 copies sold out in a day and the whole scientific world became evolution conscious.

Now why was this—why did the *Origin* produce immediately such a striking success? The answer may be found in the sub-title of the book ". . . the Preservation of Favoured Races in the Struggle for Life." Here was something that everybody could understand. The industrial revolution was in full swing. It was the age of fantastic money-making and ghastly poverty. One had only to look around and see the poorer classes unable to compete in this "struggle for existence" to understand the power of "Natural Selection."

But why was Lamarckism not taken up fifty years before? The answer here may be due to the influence of the Church. Catholic France still held sway over the masses despite the free thinking of the recent revolution. However this was not all. Lamarck had a very powerful opponent in his colleague, Cuvier, and, on the continent, *his* authority was supreme. He waited, however, until Lamarck died in 1829 before he went in to the attack. Then the eulogy he presented to the French Academy was probably the last thing that he wrote before his death in 1830. Even so we do not know what he actually said because only an expurgated edition of the eulogy was finally published in 1835. The original was too scurrilous to print!

The eulogy is in fact a complete travesty of Lamarck's views. He summarized his position on evolution in 1815 as four separate laws, of which only the second and fourth need concern us. The fourth law expresses a belief in the inheritance of acquired characters, and it is this that is taken nowadays to represent the whole of Lamarck's views. It is, in fact, his tragedy that he ever saw fit to publish this law as a separate item, for, as I showed some years ago, it is redundant in the presence of his second law. This states simply that that which is required by circumstances will appear. If a primeval fish by force of circumstances, in order to save itself or at least its kind in the struggle for existence, is obliged to swim it will evolve a tail. If an ancestral bird is forced to attempt to fly it will develop wings. *That* is the essence of Lamarckism.

This whole grand conception was turned into an utter farce simply by the misuse of a simple word—*"besoin."* "J'ai besoin de" means "I have need of" or, as we might say, "I want," but it does *not* mean "I desire." But this is how Cuvier suggested that Lamarck used the word. He took a paragraph and, after emphasizing that, in order that there should be no misunderstanding, he was using Lamarck's actual words, he paraphrased the passage, putting desires or wishes where in fact there should appear wants or needs. This mis-translation has recently been described as one of the scandals of science, and so it is. It is trivial, but coming as it did from the all-powerful Cuvier it ruined Lamarck's reputation in his own country.

But worse was to follow. A year after its appearance the eulogy was translated into English and published in a sort of gentleman's science magazine in Edinburgh. We do not know the author but the journal was edited by Professor Jameson, the most catastrophic of catastrophists, and in the translation the idea of "wants" disappears altogether and only "desires" are mentioned. It is not surprising therefore that in 1859, when a comparison of Lamarck with Darwin was so essential, this absurd wishful-thinking idea was adopted by everyone. Thus Wallace, in his original paper that was read along with Darwin's on July 1st, 1858 at a meeting of the Linnean Society, quoted Lamarck as having said that a giraffe got its long neck by "desiring" it. In fact, of course, Lamarck did not talk primarily about the giraffe's neck, he talked about its long front legs. But the important point was that he implied the needs of the giraffe and not its desires, and this could easily have been verified if anybody had taken the trouble to go back to the original source. But nobody did, and an example of the ridiculous muddle to which this omission led is

the statement by T. H. Huxley that Lamarck's evolutionary ideas could not apply to the vegetable kingdom because, of course, plants cannot desire! Amazing as it may seem, this puerility was revived only last year at the Darwin celebrations by de Beer.

An example of the extremes to which scientists who were out to decry Lamarck were prepared to go, is the statement made by T. H. Huxley in a published lecture that according to Lamarck, long-legged birds which lived on fish evolved from short legged birds, by desiring (sic) to get the fish without wetting their feet! Of course Lamarck never said anything of the sort but then, in Huxley's eyes, to use his own words, "It is Mr. Darwin or nothing." This lecture was published in a small book of *Six Lectures to Working Men* which became immensely popular and sold a vast number of copies.

It is not surprising in the circumstances that Lamarck's views were ridiculed and laughed out of court. And yet, despite this in the 1890's, when the more obvious faults of Darwin's ideas were becoming evident, there was a revival of Lamarckism, especially in America. But then came the rediscovery of Mendel's Laws in 1900. Here was the explanation of the mechanism of evolution, and moreover, one that could be tested by experiment. So Mendelism triumphed and even today, to most biologists, it forms the basis if not the whole fabric of their evolutionary principles.

IN the opening decade of the present century, Darwin's views had been abandoned largely through the work of the biometricians. Darwin believed that small continuous variations were inherited. In fact, his whole theory stood or fell by the reality of this inheritance. But Galton, who was a sort of cousin of his, showed that this was not so. Moreover, he demonstrated this by a mathematical analysis, that is, by experiment, and those were the days of the experimental method. Anything that could not be proved by experiment must be wrong, and so Darwinism went completely out of fashion.

At the same time Lamarckism was abandoned, but not because of the "wishful thinking" absurdity of Cuvier. That was apparently forgotten, and certainly nowadays few people have ever heard anything about it. It was on account of his fourth law, which postulated the inheritance of acquired characters, that Lamarck was held up to ridicule. Now this opposition came about largely by a sort of posthumous effect of Darwin's activities. Darwin, despite a lot of ill-informed statements to the contrary, believed in the inherited effects of use and disuse. Even in the preparatory sketch that he wrote in 1842 this is clear, but in the sixth edition of the *Origin* where he is discussing the origin of the giraffe he makes it absolutely certain that the inheritance of acquired characters is essential to his argument. To explain this he developed his theory of pangenesis. He put forward the idea that all parts of the body produced hypothetical particles called pangenes which circulated around the body in the blood stream and so passed through the gonads. If an organ through use or disuse altered, then its pangenes would alter and these would record themselves in the germ cells as they passed through the gonads. This conception never took on and now is only of historical interest.

To counter this idea Weismann developed his hypothesis of the Isolation of the Germ Cells. Thus Darwin, for his pangenesis, stipulated that the germ cells were in continuity with every other part of the body while Weismann said the reverse. Now this idea *did* take on. It became very popular and only last year found a fervent supporter in a senior Cambridge zoologist. But, of course, there *is* no isolation. The gonads are no more isolated than is, say, the liver or the spleen. All parts of the body *must* be in continuity through the blood stream. However, the idea of Weismann led to an absurd spate of experimentation. To begin with animals were deformed experimentally in some way and then it was shown that the deformity did not appear in the next generation. This, said those who believed in Weismann's ideas, was because the germ cells are isolated from the rest of the body and so, no matter how any organ is deformed, it cannot register that change in the germ cells. The whole history of the long series of this type of experiment is a pathetic record. Some of them are unbelievably stupid, some of them are patently fraudulent, but all are useless because the very method on which they are all based precludes the possibility of there ever being an unequivocal result. This I pointed out some years ago, but to no effect. The High Priests of Mendelian orthodoxy still persist in stating that experiment shows that acquired characters are *not* inherited. In fact the experiments show neither this nor the reverse, they show just nothing at all.

Thus when I was a student some forty years ago both Darwinism and Lamarckism, regarded solely as a belief in the inheritance of acquired characters, were completely out of fashion simply because it was said that experiment showed them to be based on false premises. And so things went on until, between the wars, it became apparent that everything was not right in the Mendelian fold. It was realized, largely through detailed palaeontological studies, that evolution was a very gradual and continuous process, as Darwin envisaged, and that the types of variation which were being studied by the Mendelians were too abrupt. Hence there arose the Neo-Mendelians who said that Darwin must be right after all. His minute continuous variations must be inherited *despite* all the experimental evidence to the contrary. All that need be done, they said, is to assume that each character is the result of the activity, not of a single gene or a few genes, but of a large number of small genes each with an effect too small to be measured, that is, too small to form the basis of an experiment. So the Neo-Mendelians, having abandoned both Darwin and

Lamarck on negative experimental grounds, now take back Darwin into the fold on a basis which precludes experimental proof from the beginning! But for Lamarck, their treatment is far otherwise. He is still outside the pale, but entirely on the grounds—the erroneous grounds—that all he believed in was the inheritance of acquired characters.

AND now what is the position in this centenary year? The views of the contemporary orthodox geneticist were made abundantly clear last year in the broadcasts and lectures and publications which were produced in connection with the meeting of the International Congress of Zoology which was held in London and centered its activities around Darwin and the conception of Natural Selection. If we are to accept these views, and there seems no reason why we should not do so, then apparently the great merit of Darwinism is that it shows how right the Neo-Mendelians are, while Lamarck, to quote the wisdom of de Beer, brought the subject of evolution into disrepute "by the fanciful nature of his views"!

Now let us see what truth there is, if any, in de Beer's claims. He states to begin with that Darwinism shows how correct is the modern view of evolution by means of natural selection and the survival of the fittest. In his actual words, "the last forty years of research in laboratory and field have proved beyond the possibility of error that Natural Selection of random variations has been the chief factor in evolution." But what he completely fails to see is that however evolution came about, whether by Darwinian inheritance, or Mendelian, or Lamarckian, or, if it comes to that, by special creation, by an Act of God, there will always be survival of the fittest *as long as there is competition to survive*. If there were no heredity at all, if like did *not* beget like, there would still be the survival of the fittest. If a pig gave birth to a litter of porcupines there would still be a struggle to survive between the baby porcupines and the other piglets, with the inevitable result that there would be the survival of the fittest. In any contest, from a Test Match through a baseball league competition to a final degree examination, there is always competition, and naturally the result is the success of the fittest. The whole idea is self-evident and the Neo-Mendelians have no more right to claim this obvious truth in Darwin's favor or in their own than anyone could claim as an original inspiration the fact that the shortest distance between two points is a straight line. The whole idea of the survival of the fittest is simply a truism.

The poet Tennyson, in his *In Memoriam* published ten years before the *Origin,* shows that he had a very sound idea of the competition that goes on among living forms. As he said when questioned as a very old man, we were talking about these things long before Mr. Darwin published his ideas. Even before 1805 Lamarck had a very clear idea of the struggle for existence. He talks about it in his writings but he takes it as commonplace and does not pursue the matter further. He probably got his ideas from Rousseau whom, as a student, he used to meet in his walks around Paris. Rousseau in his essay on the origins of the inequalities among men appears to be one of the first, if not the first, writer to publish the idea in print.

THE extraordinary thing about modern genetical research is that so much experimentation and fantastic mathematical analysis is employed to show that there must be the survival of the fittest. The whole effort is simply being wasted. If a corresponding amount of work were put into establishing that there is in fact a competition then that would lead to positive and significant results, whereas the idea of the survival of the fittest *in a competiton* is something which can no more be denied than can some simple arithmetical statement.

Now de Beer goes much further. He maintains that the only part of Darwin's hypothesis which must be abandoned is his belief in the inheritance of acquired characters. But let us see whether there is any more truth in this statement than in the one we have just discussed. To begin with, the whole of Darwin's ideas was based on a firm belief in blending inheritance. That is, he believed that when any two varieties are crossed together the offspring are intermediate between their parents. But the Neo-Mendelians know better. They know all about the independent assortment of characters. De Beer excuses Darwin on this point by saying that he was not in a position to appreciate the Mendelian idea of dominance as this only came to light some thirty years after Darwin's death. But why did not Darwin discover the error of his own views? We hear such a lot about his experiments in his garden. He was always walking about tending his hybrids. Why did he not discover, not Mendel's Law, for that is essentially a statistical law of inheritance, but the fact that when a tall pea is crossed with a short one the offspring are *not* intermediate but all tall. Mendel observed this very quickly. But what is more puzzling is that Darwin *had* before him results which showed that the idea of blending inheritance was wrong. In 1799, that is, just ten years before Darwin was born, Andrew Knight showed that when tall and short peas are crossed whichever way the cross is carried out the offspring are all tall. This he published in the *Philosophical Transaction* of the Royal Society along with other observations, all showing that the idea of blending inheritance is wrong. Darwin referred to these experiments in four separate places in his book on *Animals and Plants Under Domestication,* and yet did not see their significance.

The second point is that Darwin is said by the Neo-Mendelians to have believed absolutely in the completely random variations of all living forms. These continuous variations in fact form the very basis of his hypothesis. In this he is simply stating the very essence of Neo-Mendelism. "New hereditary changes occur spontaneously and *at random,*" stated

Waddington. De Beer said, "Mutation and variation are *random* and undirected." But then if this is so, if every part of the body is varying at random, that is, in no relation to other parts, how then do complicated adaptations arise in which all the various parts are perfectly balanced one with the other? De Beer says there is nothing to worry about, for even the most improbable things come to pass. Thus he points out that the chances that any married man will have a son, who will have a son, who will have a son and so on for one hundred generations is extremely remote—and so it is. Yet he also points out that every man among us had a father who had a father and so on back for one hundred generations! If ever there was a scientific red herring it is this. However, to return to a more profitable line of argument, did Darwin really believe as the Neo-Mendelians do in a purely chance variation? Maybe he did originally, but in 1872, when he produced the sixth edition of the *Origin,* he discusses the evolution of the giraffe and here he talks of offspring inheriting the variations of their parents or "with the tendency to vary again in the same manner." There is no ambiguity here. To Darwin organisms did not *only* vary at random as the Neo-Mendelians insist, but might have tendencies to vary along definite functional lines. This is still another fundamental difference between Darwinism and the contemporary orthodox view.

BUT the greatest fault in the whole of Darwin's opinions is his attitude to the idea of correlation between the parts of functioning systems. This really forms the very center of the evolution problem. It is functioning systems that have evolved, not dead parts. And in any living system such as a muscle complex, a blood system and so on, each represents a wonderful complex of nicely balanced parts, cooperating with all the others to produce the final efficient result. Darwin frankly did not see any reason why the various parts should evolve in cooperation with each other. He says that correlation of parts is sometimes "quite whimsical." He concerns himself with the useless sort of example that among domestic cats those with white hair and blue eyes are usually deaf. Yet he did not realize the complete correlation that *must* occur between, let us say, the front and hind legs of those same cats. Clearly if correlation did not exist the animal would be inefficient and so would be wiped out by Natural Selection. There is no question about the inadequacy of Darwin's views on this point, for in the last edition of the *Origin* he says "Although every part of the body varies slightly, it does *not* follow that the necessary parts always vary in the right directions and to the right degree." But, of course, it *does* follow —according to his own hypothesis!

This is clearly shown in the case of the evolution of the giraffe where Darwin states "those individuals that had some part or several parts of their bodies rather more elongated than usual would generally have survived." But would they? How could a giraffe with longer front legs but no corresponding long neck drink water, for surely that water is on the ground? Obviously without correlated variation only ill-adapted animals would arise and these would at once be wiped out by the all powerful natural selection.

And so to sum up the fantastic claim that Neo-Mendelism and Neo-Darwinism are virtually the same: Neo-Mendelians rely on Mendelian inheritance, Darwin on blending inheritance. The Neo-Mendelians insist emphatically that variation is completely at random; Darwin envisaged in addition a variation directed along particular functional lines. Darwin relied to a large degree on the inherited effects of use and disuse; the Neo-Mendelians scorn such an idea. And finally Darwin saw no need for functional correlation at every step in the evolutionary tree. To him the characters of an organism were like so many marbles in a box that would be changed haphazard, and if by chance the right collection of marbles turned up then that would be the one chosen by nature for survival. Now how do the Neo-Mendelians regard this problem which is, as I have said, the central theme of any evolutionary hypothesis? They are much wiser than Darwin. They see that if, by chance mutation, a gland becomes larger than its duct, its blood supply and so on must also become larger. If a muscle becomes stronger then its antagonistic muscle must vary accordingly. If a bone, again by a gene mutation, becomes longer, then clearly the muscles attached to it must also elongate. If they did not do so they would be out of action by being in a perpetual state of tension.

According to orthodox Neo-Mendelism, this is what happens. If in any coordinated functioning system a part alters by a gene mutation, that is genotypically, then all the other correlated parts adjust themselves. They alter phenotypically, that is, despite their genes and not by virtue of them. Thus, if the biceps muscle increases in strength by a change in its genic representation—if it alters genotypically—then the triceps muscle alters phenotypically. But in addition there are the dozen or so muscles correlated with the biceps muscle, the ancillary muscles that hold the shoulder firm. Now all these muscles holding the shoulder joint to the scapula, the scapula to the vertebral column and so on—all these will have to adjust themselves. They may have to become stronger or they may have to alter their points of attachments, and all this will take place as a result of one small gene mutation related to one part of the functioning system. It all becomes necessary, in order to keep up the efficiency of the system; otherwise the system would simply end. Put another way, all these changes, whatever they may be, become necessary, and so they appear. That is the position of modern Neo-Mendelian form, as culled from the latest books on the subject. But is this not also sheer Lamarckism? Of course it is—"what is required by changed circumstances will appear." Thus the modern orthodox conception of the working of the hypothetical polygenic

system of inheritance relies entirely, as far as an explanation of the mechanism of evolution is concerned, on the working of Lamarck's second Law!

But the Neo-Mendelians say these phenotypic—but nevertheless Lamarckian—responses are only temporary. Soon, they say, they will all be drawn into the Neo-Mendelian fold by Natural Selection picking out for survival the appropriate collection of polygenes so that the Lamarckian effects cease to be such and become Mendelian effects. Maybe this is so, but we should remember that this is utter hypothesis, and (to some of us) utter nonsense. However, let the Neo-Mendelians have their way and consider again the biceps muscle system. In this one simple system there must be some thirty muscles directly concerned in bringing about the efficient working of one biceps muscle. Now according to the contemporary genetical theory every organ is continually mutating at a definite mutation rate. Hence on their own hypothesis, long before all these thirty ancillary muscles have been drawn into the gene complex, one or other of them will themselves mutate. And this will at once upset the apple cart and put everything out of adjustment and so a whole host of phenotypical or Lamarckian responses will of necessity occur. Thus at any one time in any organism, even supposing that there is a grain of truth in the Neo-Mendelian hypothesis, there will always be far more characters of Lamarckian origin than those under Mendelian control.

SO, to sum up in this centenary year, all that is left of Darwin's hypothesis is the reality of the survival of the fittest in the struggle for existence through the agency of Natural Selection—and this, as I have said, is really no more the special property of Darwinism than of anybody else because it is a simple truism. Yet out of all this wreck the Neo-Mendelians who call themselves Neo-Darwinians have built up an hypothesis of excruciating complexity, an hypothesis which has recently been defined by an anonymous author as one which "consists of assigning names to hypothetical lumps of stuff in order to confer magical virtues on them, so that a crowd of lumps can bring order out of chaos and unity out of multiplicity." When all this phantasmagoria is analysed and examined in detail it becomes evident that through all the welter of hypotheses and argumentation of the last century and a half, the one thing that stands out firmly and is agreed upon by all, whether Neo-Darwinian or Neo-Lamarckian, is the ability of an organism to adjust itself appropriately to changes which affect its functioning so as always to ensure the preservation of itself or its kind. And is not this the real and true Lamarckism?

But evolution is not merely the "origin of species." This is the incomplete idea which has arisen owing to the inaccuracy of Darwin in choosing the title for his greatest book. As has been said recently, he was not interested in defining the terms he used. The actual speciation of forms, the origin and establishment of those trivialities which lead to interspecific sterility and the appearance of new species, this is a problem in itself and lies without doubt in the field of Neo-Mendelism. But this represents only the ultimate twigs of the evolutionary tree. The main branches of that tree all represent major advances of a functional nature. At each great step there are either new organs which put in their appearance or else old organs are put to new functional uses. And so all the main advances must involve, whichever view one takes, a mass of Lamarckian responses.

Mendel, in his old age, is reported as having said "My time will come." It is doubtful whether poor old Lamarck ever had such hopes. But now in this centenary year is it not clear that Lamarck's time *has* come and that he can surely now lay claim to the title given him by his great American biographer, Packard—the Founder of Evolution?

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SCIENCE AND ART – A COMMENT

Hilaire Hiler

ON the first page of *Science* for March 13, 1959, Mr. Joseph Turner, Assistant Editor, reviewed the *Bulletin of the Atomic Scientists* for February, 1959. The title of his review is "Science and Art," for the entire *Bulletin* was devoted to a series of ten essays on this general subject. Marston Morse, Professor of Mathematics at The Institute for Advanced Study at Princeton, concluded the discussion with the conventionally accepted view that "the two activities are as different as the activities of the mind and the heart." H. W. Janson, Professor of Fine Arts at New York University, undertook a defense of the currently fashionable Abstract Expressionists.

Since I am an artist who has been trying to use scientific method in design for the last ten or fifteen years, I should like to make a few comments in refutation of what I consider a type of split thinking which is as overabundant as it is popular. For my own conclusion has been that scientific method can be of great help to the designer, that his activities are inseparable from those of science on many levels, and, in fact, that the use of scientific method on his problems will eventually prove to be as sensationally successful as it has been in other fields.

Bertrand Russell and L. L. Whyte are two of many philosophers and/or psychologists who claim that the "emotions" and the "intellect" cannot be separated except verbally.

Music is perhaps the most scientifically developed of the arts but architecture—"that frozen music"—can scarcely function without recourse to scientific principles. The mathematical aspects of these activities, as well as those of techtonic design and the contemporary school of painting called "cold abstraction," use these mathematical principles in a way that is neither novel or subject to much controversy. Mathematics may be considered a language of order, relations, structure and logical progression, $x=f(n)$. Such instruments as logarithmic paper, proportional dividers and adjustable triangles may be bought at any draftsman's supply store. That they are used by some designers should not be surprising.

Physics began furnishing data for color relations when Newton analysed the spectrum. The physicist Ogden Rood of Columbia influenced the French Impressionist painters and—more profoundly—Seurat. Physics now provides artists with accurate measurement and the possibility of permanent registration and symbolization of their colors. Such men as Fechner, Hering and Ostwald, pioneers of psycho-physics, made the development of our elaborate and beautiful color-order systems (such as the one exploited by the Container Corporation) possible.

Chemistry has furnished the artist with balanced and continuous runs of brilliant lightfast pigments as well as many other important and ingenious materials. That many of our painters seem determined to mix them back into mud is hardly the fault of too much scientific method.

Mathematical biophysics, as begun by D'Arcy Thompson in his monumental *Growth and Form,* offers aesthetic implications too widely known to need stressing here. It has also provided means for highly refined aesthetic experiments such as those performed by Rashevsky and his colleagues at the Institute of Mathematical Biophysics at the University of Chicago. The fascinating observations of Dr. Paul Weiss in the field of bioaesthetics are another example of the connection between science and art.

Geometry gives the artist a method for visual organization. The remarkable set of figures, signs and symbols used since antiquity is certainly as interesting as the set of curves formulated from organic sources. Color photography, which some of us think may have freed the artist for design or abstract principles of relations rather than more purely mimetic activities, is now also revealing a fresh new world of structure when combined with the electron microscope. Pigment-color, again thanks to photometric devices, is now a well structured and ordered limited collection.

Contemporary psychology, as experimental aesthetics or *gestalt* psychology, furnishes much material which could be of great interest to the artist-designer. A social psychologist like A. H. Maslow has been able to perform experiments on the effect and affect of our surroundings which point sharply to the need for design in our culture.

Investigations into the nature of creativity made by Viktor Lowenfels, Kenneth Beitel and Lambert Brittain at the School of Art Education of the Pennsylvania State University agreed in their conclusions with those carried out quite independently by Dr. J. P. Guilford at the University of Southern California although the latter was investigating "creativeness in science." The results (1958) pointed to "common attributes of creativity in the sciences as in the arts."

I do not mean to imply that the scientific method is useful to all artists for the creation of all types of design. In some cases its use proves so delightfully fascinating that once a designer has become acquainted with it, it would be quite impossible for him to return to the prescientific state of mind.

Semanticists and philosophers (Suzanne Langer is an example), as well as semioticians such as Charles Morris, are becoming deeply interested in some problems of the visual arts.

Much more such work needs doing in connection with the language of painting which is archaic, episte-

mologically hopeless and, as Wassily Kandinsky said, "suffocatingly confused."

Sergei Kadleigh, A.R.I.B.A., Hon. A.R.C.A., of the Royal College of Art, London, read a paper titled "A New Grammar of Ornament?" which was published in the Journal of the *Royal Society for Arts,* October 11, 1957. After mentioning quantum mechanics and "waves and particles" and such names as Born, Heisenberg, Schrödinger and Dirac, he said: "I do not think it is stretching things too far to say, in consequence, that modern nuclear physics provides us with a scientific basis for the rules of proportion, symmetry and scale which up till now have only had a philosophical basis. Far from denying the existence of such principles, modern science substantiates them and increases our knowledge of them."

SOURCE READINGS: INTEGRATIVE MATERIALS AND METHODS

Reality, Determinism and the Russians

MAX BORN, in an essay entitled "The Concept of Reality in Physics" in the *Bulletin of the Atomic Scientists,* October, 1958, makes some suggestions toward a philosophical reconciliation between the Russians and the West. The suggestions grow out of his attempt to sharpen the definition of our concept of "reality," by examination of the way our naive ideas must be extended if they are to fit, in complementary fashion, with the theories of modern physics.

Born reminisces regarding the growing strangeness, beginning sixty years ago or so, between the language of physics and the language of the everyday world. Today's "atoms, nuclei, electrons, mesons, fields" have properties which do not at all resemble those of ordinary bodies and yet they have a reality for the physicist. It almost seems as if physics has now two sets of realities.

This, however, is unsatisfying philosophically. A retracing of steps shows that there is no sharp limit between the everyday world and the microworld. For example, a crystal of common salt certainly belongs to the ordinary kitchen world. One can grind it to a fine powder until the particles can be seen only with a microscope, and then finally only with an electron microscope. Born asks, are the particles of the powder therefore becoming decreasingly real? Born's point of view is, therefore, that "physical models have a definite content of truth, which is not essentially different from that of the things in daily life."

"Things" are inseparable from his notion of reality for, as he says, our starting point for the "objects" of physics must be the everyday things and the words of our everyday language. It makes no sense to go back to disjointed "sense impressions" as the raw material of physics, since as much of a mental process is requried to dissolve objects into single sense impressions as to arrive at any other abstract component of a theory. "Single sense impressions are not what the positivists believe to be the 'primary data' but abstractions." What are actually given are certain invariant characteristics of the sense impressions which we describe as "objects" or "real things." He bolsters this view by citing present knowledge of the physiology of sense perception. The sense organs send to the brain sequences of electrical pulses having nothing in common with the source of excitation. The brain somehow solves for invariant properties and reconstructs our perception of whole things and structures. Science, similarly, is a process of extracting invariants. Hence the importance of mathematics.

Born recalls that his criticism of positivism brought him favorable notice from the Russians, particularly from one Professor Sergei Suvorov who said, "In Marxist terminology positivism is a subjectivist and idealistic teaching; such teachings are rejected by materialists." Suvorov also said, "The modern materialism, in generalizing the development of science in all fields, says that to know an object means to discover the objective relationships which are specific for that object." Born sees no essential difference between Suvorov's "specific relationships" and his own "totality of invariant properties," and sees there the germ of reconciliation, once some simple differences of language can be brought to terms. After all, the physicists in East and West understand each other perfectly well. Both, for example, get excited about Heisenberg and Pauli's spin theory of elementary particles. "Distinctions based on the scheme 'materialism' do not correspond with the facts of our time."

The roots of the apparent disagreements lie in the past. Marx and Engels, for example, knew nothing of today's relativistic and atomic physics. In their time "matter" was what our senses conveyed it to be; physical measurements dealt with the sensually perceivable properties of things, and Newtonian mechanics held sway. For them the determinism of Marxist historical materialism was a natural extension of the principles of physical science. Since then, however, not only the indeterminacy of quantum mechanics, but also the ideas developed by Born and Hooton on the propagation of measurement errors have been enough to discredit the idea that the laws

of nature should permit us to predict with absolute certainty all that is going to happen in the future, if only the initial state is fully known. Born's particular contribution has been to demonstrate that, even without quantum mechanics, admitting only the very practical and realistic consideration that every actual physical measurement contains some element of imprecision, a point will be reached in the development of events beyond which prediction will become impossible. Thus Born claims to have proved that "determinism is out of the question in the original sense of the word, even in the simplest classical science, that of mechanics . . . and to apply the idea of determinism to historical events is simply fantastic." Even in the world of Marx and Engels, under the influence of astronomical predictions, this point could have been just as obvious if anyone had thought about it. "Today," believes Born, "no scientist should make obeisance to determinism—of which historical materialism is an offshoot." Born here seems to ignore the philosophical problem that an absolute determinism of which we are ignorant because of imprecision in measurements is not the same as an absolute content of indeterminism injected into the world by free acts, though one must admit that the difference should be purely academic and immaterial to the historical realist which, presumably, a Marxist would pride himself on being. Of course the possibility would still exist that the Marxist could regard his theories as valid within a certain time span, but in fact, once he had accepted the point in principle of limited predictability, he would surely find himself and Western scientists in agreement. What Western sociologist would deny that at least some laws are discernible in the behavior of societies?

To end this slight digression, it is in some such way that Born hopes to reach agreement with Suvorov. He is encouraged by the situation that even among Marxists there is doubt and argument as to what their official doctrine should be. On the one hand some Marxists vehemently attack the Bohr or Copenhagen interpretation of quantum mechanics as incompatible with dialetical materialism and, on the other hand, other Marxists see in Bohr's complementarity concept a striking example of the dialectic development defined by Hegel. At the same time Marxism claims to be the only valid scientific interpretation of the world. The liberal capitalistic West is not without fault either, calling itself Christian, but in its policies paying no attention to Christ's teachings. These arrogant and rigid dogmas Born sees as ominously reminiscent of the theological controversies of the 16th and 17th centuries, which ended with the catastrophe of the Thirty Years War and the devastation of Germany. "Today, in the age of the atom bomb, the whole world would be devastated, if the field were left entirely to dogmatic politicians." But there is still hope in the direction of the physicists, for "philosophical dogma should have no place in the interpretation of natural science, and . . ., conversely, physics is not a proper basis for the derivation of such dogmas. . . . I hope that physicists can make a contribution toward international understanding by renouncing the extreme ideas of positivism as well as of materialism. Above all, we must make away with the fairy tale of physical determinism and thus also with the specter of historical inevitability."

—Ray W. Jackson

The Genetic Basis of Culture

THERE is perhaps no problem more perplexing, and yet more inescapable, than that of human destiny. It was old and much debated when Darwin wrote *The Origin of Species*. . . . We may not yet know what life is, but we do know that all life, including man, is one, related by common descent."

Theodosius Dobzhansky, Professor of Zoology at Columbia Univesity, and well-known geneticist, writes on the subject of "Genetics and the Destiny of Man" in the Spring 1959 issue of *The Antioch Review,* and discusses some of the problems and the questions facing geneticists today. Despite the burgeoning of knowledge about the genes and such agencies of mutation as radiation (both natural and man-produced), environmental factors, and the factor called natural selection, the basic questions as to the "why" of genetics still remain unanswered. The author writes:

"The human body starts its existence as a fertilized egg cell, weighing about one-twentiethmillionth of an ounce. An adult is some fifty billion times heavier. The growth occurs through assimilation of food. Quite literally, man is a conglomeration of transformed groceries. And yet, this conglomeration is alive, feels joy and suffering, is conscious of self, and of the existence of other persons and of the Universe.

"How is this possible? How can groceries be transformed to living matter? The nearest approach to an answer is that this transformation is brought about by the action of the genes which man has inherited from his ancestors. . . ."

Genes are most remarkable bits of tissue. Composed primarily of deoxyribose nucleic acids associated with proteins, the gene in some manner can replicate itself, constructing a copy of itself from materials in its environment, ultimately from food. If self-reproduction is the basic property of life, then the gene is the basic life unit, and the genetic specificity and all genetic information is resident in their nucleic acids. Since genes appear to come only from genes, all living things can trace their family lineage back to the primordial protoplasm itself—a family history of more than two billion years.

Whatever these primordial genes may have been, our genes are surely different. The human sex cell may contain tens of thousands of genes, each a product of aeons of evolutionary development by successive mutations. Such evolution is not simply the summation of mutational steps, it is the accumulation of *useful* mutants, and only an insignificant fraction of

the mutants which arose in man's ancestry have become constituents of the present human genotype. Evolution is a response of living matter to environmental opportunity, the outcome of a triangular encounter between environment, mutation and selection. This results in a continuous re-patterning of the genes, of which Dobzhansky writes:

"I think we must definitely reject the notion that mankind has not changed genetically to any appreciable extent since the inception of the human cultural phase, one hundred thousand or more years ago. Human genes have been constantly patterned and repatterned by natural selection, precisely because they made possible adaptation to the environment by means of culture. They bestowed upon our species the ability to communicate by means of symbolic language. Human genes have ushered in an increasing refinement of what Pavlov has termed the second signal system, concerned with symbol formation and symbolic thought. The genetic basis of culture is the greatest achievement of biological evolution, and it is utterly improbable that it can remain static for any length of time."

Concerning mutations, in connection with the problems of radiation produced by the usage of atomic energy, the author points out that we cannot classify a mutation as "good" or "bad" — nor a genotype as favorable or unfavorable — unless the environment is also specified. The environment of the Machine Age is not the same as that of the Stone Age; a mutation which is "good" for one might well be "bad" for the other.

Changes in the genetic pattern tend very quickly to become distributed throughout the germ plasm of the species through the mechanism of sexual reproduction. With intelligence, however, this can become an opportunity for man, rather than the heavy responsibility it may appear. For genetically, all mankind is a oneness. The author concludes with these words:

"Our species, mankind, is a single genetic unit. The atomic bombs which exploded over the cities of Hiroshima and Nagasaki have doubtless induced mutations which will not be confined to the populations of these two cities. They will be added to the genetic loads of the population of Japan and ultimately of the world. When we consider a problem like that of genetic damage likely to be caused by radiations, nobody can be satisfied if only he has not suffered radiation exposure. The future of my genes depends ultimately on that of everybody else's genes. Genetics has vindicated the great words of John Donne: '. . . any man's death diminishes me, because I am involved in Mankind.'

"With Western Civilization rapidly acquiring the character of universality, this imposes upon man a great responsibility. For mankind will from now on inescapably be the moulder of its own destiny, and perhaps of the destiny of all life in the Universe. In man, the process of evolution has created its own directing center. But direction requires knowledge. I can hardly do better than to conclude this article by quoting Teilhard de Chardin: 'Taken in the full modern sense of the word, Science is the twin sister of Humanity. Born together, these two ideas, or two dreams, have grown together, until they attained a quasi-religious value during the last century. They have also known the same dishonors. Which does not prevent them, supporting each other, from always representing the ideals to which our imagination comes every time it tries to materialize on earth its reasons for its faith and its hope'."

—*Alan Mannion.*

Science and the Search for Meaning

IN the March issue of *American Scientist* there is an important article by Cornelius Lanczos entitled "Albert Einstein and the Role of Theory in Contemporary Physics," which discusses and contrasts the experimental or inductive method in scientific investigation with the theoretical or deductive method, with particular reference to the contributions of Einstein.

Reviewing the historical development of modern science, Lanczos points out that although Galileo is usually credited with being the father of the experimental method, he insisted on the necessity of experimentation not as a final goal but as a means to an end, this end being the discovery of the *law,* "because the universe is a lawful organism in which nothing can happen by chance. Moreover that law must take a very definite form, it must be a *mathematical* law." Galileo rejected the Aristotelian view that quantity is only one of the categories by which the nature of things can be conceived. Believing that the senses are deceiving through the multitude of qualities which they present, he regarded reality as existing in the relation between numbers. This attitude founded a new program for the exact sciences, wherein the possibility of resolving all qualitative differences into quantitative relations became a basic postulate.

After considering the methods and contributions of a number of scientists, from Kepler to Maxwell, Lanczos discusses the work of Einstein: "What Einstein did was not a formal accomplishment. . . . Something much more fundamental was at stake, namely, the critical evaluation of the entire foundation of theoretical physics. Certain things which were always taken for granted were put under scrutiny and their falseness proved. This was no longer mere physics and mathematics. This was a combination of philosophy and physics and mathematics. The experimental side of physics was by no means neglected. But the point where the experiment came in was somewhat shifted." With Einstein, theoretical physics entered a new phase of development. The evolution of his thought was accomplished essentially on speculative grounds, urged on by his desire to understand and not merely to describe. To him the mathematical laws distilled from experiments and codified into postulates were to be examined philosophically

and re-discovered, not as descriptions of experiments but as necessary emanations of the logical structure of the universe. "This was an achievement that made the originator of this theory the founder of a new scientific philosophy and the fountainhead of a new era in the history of human thought."

In spite of this, there was a good deal of resistance to Einstein's accomplishments. As Lanczos says, "The entrenched positivistic outlook of physics could not be shaken by the great intellectual achievement of Einstein's new world picture. Why should we give up a simple description of a natural phenomenon in favor of a much more complicated one only because the latter is intellectually more satisfying?" Furthermore, another great revolution of contemporary physics, quantum theory, developed along lines which were in many respects directly opposite to the evolution of relativistic speculations. "The leading urge in Einstein's struggles with the problem of relativity was the philosophic desire to understand. . . . In quantum theory, on the other hand, certain strange and obscure principles are forced on us . . . merely out of necessity to bring order into an otherwise incomprehensible maze of bewildering observations." At the time when Einstein announced the new principle that every mass by its very existence is the seat of a tremendous amount of energy, there was not the slightest experimental evidence to support this purely theoretical conclusion, which was proven by the atomic explosion almost forty years later. On the other hand, the law in quantum physics expressed by the equation which associates a definite energy content with every vibration of the frequency n is forced upon scientists by empirical evidence and must be accepted at face value.

"So, we see the two great theories of contemporary physics, Relativity and Quantum Theory, developing from opposite corners and viewing each other with a certain hostility. Einstein was convinced that nature cannot be reasonable in one corner and unreasonable in the other." The victory in the field of gravity gave hope that cautious generalization could enlarge understanding of nature's inner meanings. Einstein's dream was thus to enlarge the field of relativity with the final goal of including all phenomena of nature in one unified scheme. But professional physicists greeted his efforts with silence and indifference. Lanczos accounts for Einstein's transformation from a genius of world renown into a person little regarded, as follows:

"The explanation frequently offered is that the modern formulation of quantum theory demands Heisenberg's 'uncertainty principle' while Einstein was unwilling to depart from the strict determinism of classical physics. In actual fact, the antagonism has much deeper roots. It is associated with that complete change of intellectual and cultural values which took place in the course of Einstein's life." The social upheaval which resulted from the rise of totalitarianism and World War II led to an extreme pragmatism which denied any shade of transcendental orientation. In the postwar period, the increased demands of industry and technology obliged the scientist to focus upon problem-solving, to do research, and to make fresh discoveries every year. In Einstein's time, the scientist had no such compulsions; "science was not a career, not a social position, not a job, but an inner obsession."

"The changed social scenery had profound effects on the scientific climate of the times. Quantum theory provides us with a certain mathematical mechanism which allows us to go through certain mathematical manipulations and obtain the desired answer. If we do not understand what we are doing, why should we bother, as long as the answer is correct? The only important thing is to predict the results of experiments. . . . The idea that there is a 'meaning' in the laws of nature is rejected as not worthy of serious consideration. . . . Quantum field theory has still its limitations, but we can imagine that the day will come when we will be in the position to give an answer to all reasonable questions. We will then have a scheme comparable to a language whose words we do not understand, but whose syntactic rules we possess to such an extent that we can construct flawless sentences in that incomparable language. We will then have everything we need because we will be able to predict, at least in the statistical sense, the results of any conceivable experiment." In this way science can fulfill the social pressures and demands made upon it by our age.

To controvert this attitude, Lanczos makes two points: first, the change which relativity made in the basic concepts of physics cannot be lightly dismissed, and second, in spite of all mechanization, men are human beings, not automatons, and they have spiritual needs which must be satisfied. "The majority of us will never believe that the Cosmic God acts on the basis of mere chance or that the laws of reason are not applicable to cosmic happenings. . . . In spite of all discouragements on the part of the paragons of modern physics, we will continue to look for a unified structure which we feel must exist behind the appearances. . . .

"Finally, let us assume that it is in fact true what the representatives of modern physics claim, namely, that the present foundations of quantum theory are absolutely the final ones which will never change. . . . In that case, Einstein's work assumes a significance which will never be repeated again. Pragmatism and positivism have been with us for hundreds of years. But it happened in our own day that somebody dared to challenge the physical universe with philosophically sound questions and obtained philosophically sound answers. . . . The work of Einstein has shown that refined abstract thinking, armed with the mighty tools of advanced mathematics, can penetrate into territories which were never before open to the human eye. In an historical period of unprecedented destructiveness, in which irrationality and the aggressive instincts of mankind celebrated triumphs of appalling magnitude, we find a quiet oasis of peace and silence in which the mind plays on sunny meadows and demonstrates the invincible priority of the power of logic and reason."

—E. B. Sellon

NEWS AND NOTES

THE Colloquium on the Nature of Man is performing a specific service rendered at present by no other institution, and the address by Professor Andrews printed in this issue is a case in point. We feel privileged to serve his sponsors and our readers by its publication and thus express our appreciation of the fact that the Colloquium continues to act as an effective center where the nature and significance of the new knowledge are conjoined with inherited culture.

That function is not undertaken by the extant Institutes for Advanced Study. Public and educational affairs in this country might be different if they were explicitly designed for such work. In the case of the Institute at Princeton the restriction of purposes we refer to is a particularly obvious deprivation to the nation. For it is well known that its chief, Dr. Robert Oppenheimer, is both gifted for and inclined to inquiries that do not end with science, and that the Institute has entertained scholars who have occasionally carried the discussion along—not only Einstein and Hermann Weyl from science but Jacques Maritain and perhaps others from theology. But all that is very different from an avowed responsibility to force the issue by systematic assembling of data.

The difference between the purpose seen in the recorded program of the Colloquium (on the one side) and the present Advanced Institutes (on the other) can be embodied in two words: The former attends to what is *basic,* the latter to what is *advanced.* Advanced study formulates and conserves gains made. Basic study can serve to integrate such gains and thus disclose their total, as against their specialized, meaning as to man and nature, taken as a whole. It should be cause for dismay that we have more than one center well equipped for the former purpose, and none for the latter.

In order to be specific about the assembling of data with which to force the issue without authoritarianism, we ask the reader to consider the total meaning of the following, not each item taken alone, but what all signify in conjunction, and the effect such established insights would have if formulated and taught as part of systematized universal knowledge. The statements below can, of course, be demonstrated convincingly through educational materials. We do not pause here to expand the argument, but only mention a few celebrated names specifically associated with the points made.

Fundamentally, space-occupying matter does not exist. Instead we have orderly arrangements of what are, for the most part, electrically charged particles and pseudo-particles, each arrangement expressing dynamically the geometric properties of force fields, as shown by James Clerk Maxwell and a galaxy of geniuses. Next, as to the symmetries and harmonies and resonance forces, there are many instances of what seem to be disorder at a given low-dimensional level which, when re-examined from a higher-dimensional level, turn out to be temporal sequences and spatial arrangements that are merely partial expressions of a constancy and a reality that can be demonstrated to govern from above. Here one thinks of Kepler and Newton in regard to astrophysics, and of Niels Bohr and others as to microphysics. One such higher level (space-time) is so fully documented, thanks to Minkowski and many others, and so regularly in use in thousands of laboratories every day that only those who are incapable of entertaining two ideas simultaneously can doubt the reality of that domain. Unfortunately it is treated almost entirely operationally in most institutions of higher learning. Finally, we have advanced to the point where certain force fields can be shown to exist in their own non-material right, their existence being demonstrated, of course, by the forms and processes through which we must necessarily study them. Here Einstein, Schrödinger, and once more Maxwell are great names. Thus it is possible to show that Nature must be looked upon as the flowing and flashing and clinging garment of a cosmic Ideation.

As to man, the history of mathematics shows that his rational-intuitional mind operates in and on the same above-noted structural-dynamic principles as does nature. We must accept this because geniuses in mathematical creativity have displayed the rationale of higher dimensions and the peculiar value therein for the resolution of apparent disorders in lower dimensions, doing this in some instances long before science needed such information to apply to nature. Since some of these discoveries were made in mathematics first and disclosed in nature only afterward, it follows that the *mind* of man must be taken as a phase of the status of man as a microcosm. That is to say, we are not only made of the same stuff physically and chemically, and embody the same principles biologically, as are displayed everywhere else in the universe, but, as beings who reflect and reason, we can anticipate what nature turns out to be doing. Thus the mind of man (whatever may be the status of the spirit) is seen to be a small and perhaps in most instances a somewhat murky mirror of the Ideation. The examples are many. To begin with there is the simple case of the 47th proposition of Euclid. A more striking and more recent demonstration of the sovereignity of reason appeared when William Rowan Hamilton endeavored to work out in three dimensions what is seen with complex numbers in the plane of two dimensions. It could not be done. He had to appeal to a four-dimensional region, hence the discovery of quaternions.

It should be evident that the foregoing considerations are compressed explosive truths just as important for man, and far more beneficient than, nuclear

forces in bomb form. Yet we have no permanent institution which attends to the argument that leads *by documentation* from the sciences to the humanities, from science through philosophy to thoroughly rational religious principles.

The Colloquium on the Nature of Man is only a few years old, and has resources just sufficient to enable it to keep alive the great topic—Man as a microcosm—by bringing into this series distinguished philosopher-scientists. Eventually what is here implied is sure to be fully implemented. Let us pray that when that time comes, the work will be committed to the hands of those who know how to do it. They are not many, and are greatly outnumbered by comformists and status-seekers. Pioneering is inveitable, if one's faith is in a search for the truth. For truth is hard to come by. Let us be thankful that the quest is thus steadily sustained. The cultural communities of this country are in debt to the founder of the Colloquium, Mr. William Perry Bentley of Dallas, and to his collaborating scientists.

The second coast-to-coast tour by Dr. C. Gattegno, secretary of the International Commission for the Study and Improvement of Mathematics Teaching, has ended. His reward is in the doing, and in the gratitude of teachers, matched by that of scores of children expressing (naturally enough) affection for this challenging teacher and (less usual!) delight in mathematics.

The fatal illness and death of Harvey W. Culp has brought irreparable loss to the editors and readers of MAIN CURRENTS, and to the officers and associates of the Foundation for Integrated Education.

Harvey Culp has served MAIN CURRENTS notably, both in his perceptive reviews and in his articles directed at integrated education, which always went straight to the heart of the matter and illumined the important issues. He served the Foundation for Integrated Education in his capacity of Public Education Consultant with ability, with courage, and with a very knowledgable zeal, for his experience in education was considerable, and his insight into the fundamental problems was great. It is a source of comfort and satisfaction to know that he was able, before his death, to complete a manuscript which contains the essence of this experience and this insight.

His services to the city of Ossining, New York, as President of its Board of Education, were so distinguished that, as a mark of respect and affection, not only the public schools but the parochial schools as well closed to pay him tribute. He was, in fact, an intellectual and spiritual force in his community and to his associates—that rare combination of courage and integrity, of mind and heart, which men always value and remember. —*F. L. Kunz*

REVIEWS

A Leonardo to Match Freud's

AT last we have been given a psychological study of Leonardo da Vinci that is strong enough to stand comparison with the classic study by Sigmund Freud. This contribution by Erich Neumann, a Berlin-born disciple of C. G. Jung now residing in Tel Aviv, is, to be sure, a brief and speculative sortee into the field. It is dealt with in the first of the four essays collected in this volume, *Art and the Creative Unconscious,* (Bollingen Series LXI, Pamtheon Books, New York, 1959, translated by Ralph Manheim, 205 pages, $3.50), the others being mainly theoretical discussions of art from the point of view of Jung's analytical psychology. But the great value of Neumann's essay on Leonardo is that it provides us with a basis for comparing the Freudian and Jungian approaches to art, and for judging their relative usefulness in understanding the creative activities of personality.

Freud's study of Leonardo holds a most significant place in the history of depth psychology. When it was written, it revealed quite clearly that the intent behind psychoanalysis was much more than a medical theory of neurosis. Freud's goal was a psychological approach to the humanities as a whole, and especially to the understanding of creative persons. That this should be so was inherent in his work, for, despite his self-disclosed anxieties, Freud was, as Otto Rank pointed out, fundamentally a "creative type;" and the personal need that was therefore bound to be expressed in his researches led him to investigate the psychology of the "artist type." Ernest Jones' biography of Freud amply verifies this.

The question that is open is not whether Freud wanted to study the process of creativity, but whether his psychoanalytic conceptions were adequate for the task. This is why the possibility of a comparison with a work written from an alternate point of view, as Neumann's study of Leonardo, can be of great value. Comparing may give us a clue as to the criteria for an adequate theory of creativity.

Freud seems to have realized that his own conceptions were not sufficient. Toward the close of his study of Leonardo he remarked reluctantly but truthfully that the essential creative factor at work in the life of Leonardo did not seem to be "psychoanalytically accessible" to him. His diagnoses of Leonardo had disclosed some of the factors that limited his creative work, but not the secret of the creativity itself. Thus Freud scrutinized Leonardo's childhood, discovered a relationship of great closeness between the mother and her young son, and then a period of separation and longing for the mother. The enigmatic smile upon the Mona Lisa was thus, for Freud, a sign of Leonardo's yearning for his mother who had been mysteriously taken from him. It was because of her, Freud theorized,

that Leonardo was deprived of the masculine power of his sexuality so that he expressed his libidinal energies instead in an insatiable urge toward perfection in art and in a boundless curiosity about science.

This line of interpretation is of course characteristic of Freud's psychosexual approach, and one finds in it the modifications of creativity, but not the sources of creativity itself.

How then does it look to Neumann? Significantly, he begins by emphasizing the same facts as Freud, and by proceeding from a similar point of view. He also calls attention to the early years of Leonardo's life. Neumann emphasizes, as Freud did, Leonardo's fantasy that while he was still in the cradle a vulture came down to him and inserted its tail in his mouth. Freud had interpreted the vulture as a mother symbol, and the fantasy as indicating Leonardo's unconscious wish to return to his mother's breast.

Here Neumann's comment is that Freud was much more correct than he knew. The incidental fact that the bird in Leonardo's fantasy seems actually to have been a kite rather than a vulture only emphasizes to Neumann how sound Freud's intuition was. He perceived the *mother* significance of the image that came to Leonardo with great force in his early years and remained with him throughout his life.

The difference between Freud and Neumann lies mainly in the fact that while Freud relates Leonardo's mother fixation to the mother who actually brought him forth from her womb, Neumann relates the entire constellation symbollically to a non-personal mother, an archetypal "great mother" that does not correspond to any specific individual but is rather a pattern of psychic realities unfolding within the psyche of Leonardo. Thus Neumann characterizes his work as an "attempt to substitute a transpersonal interpretation for [Freud's] personalistic derivation of the fantasy from Leonardo's relation to his personal mother."

What is the meaning of these transpersonal images? They are natural, formative tendencies in the psyche of man as a whole, impersonal, archetypal, universal, unfolding as far as they are able in the life of individuals. Thus Neumann writes of Leonardo, "Unknown to himself, his whole life was directed by the tendency toward an integration of his personality, which experienced itself in the likeness of a godhead encompassing in itself the higher and the lower, heaven and earth." (p. 33) It is as though a process of integration is at work in the very structure of the individual presenting impersonal psychic principles that are the basis of the growth of personality. This is the conception that Jung has spoken of as "Individuation," and it is perhaps the cornerstone of the Jungian contribution to the understanding of man.

Here, in Neumann's application of Jung, however, particular attention is directed to a special "stage" in the individuation process, the stage at which the psyche is dominated by the attachment to the "mother," the archetypal symbolic mother, the "Great Mother," or as Neumann also refers to it, the "Great Round." "The creative man," Neumann writes, "is very largely fixated in the matriarchal stage of the psyche." (p. 19)

We get the impression, then, that after an analytically intricate and sometimes exciting journey through the labyrinths of mythology, Neumann is letting us out the very same door that Freud did. He has provided some exceedingly subtle and sophisticated reasons why creativity gets bogged down and why it limits itself in certain forms. But the secret of creativity is still as inaccessible in this book as it was in Freud's.

The question then remains of whether when Neumann's study of Leonardo is placed side by side with Freud's, it can be taken as an adequate representation of what the Jungian point of view has to say on the matter. Perhaps we can say that it represents that side of Jung's work that faces backward toward Freud, still analytically intellectual in its reduction of symbols to archetypal complexes instead of to personal complexes, and still inordinately influenced by German romanticism. There is however, another side of Jung's work that expresses the dynamic vibrancy of the spirit in its movement toward wholeness, and we may hope to see this other aspect developed in further books from Erich Neumann's pen.

—Ira Progoff

Reality as the Unitary Whole

REALIZATION of the essential unity which underlies and penetrates all phenomenal diversity comes to many people, but usually as a deeply buried and unfulfilled intuition. The universality of this unitive concept is attested by the fact that it is core teaching in the great religions, and appears as a central postulate of philosophers and mystics of all ages and cultures. In science, as well, one of the marks of a successful theory is its simplicity and the elegance whereby diverse events and phenomena can be embraced in one briefly-stated principle. Here, as elsewhere, meaning and power lie in the ability to resolve the apparent chaos of discrete elements into a structured and ordered *uni*verse —a cosmos.

Yet, as Agnes Arber points out in *The Manifold and the One* (John Murray, Lon., 1958, pp. 146, bib., index 18s), this idea of Reality as an underlying unity has usually been treated as a basic postulate only—as an intuition or first principle accepted as "given." Mrs. Arber's view is that it should be regarded as an hypothesis, subjected to scrutiny, and established, so far as possible, through evidence of probability.

Using this method, the author has taken as her postulate-hypothesis the statement that there is a Unitary Whole: the noumenal Reality which is both transcendent and immanent, which gives existence to all phenomenal forms and of which all aspects of knowledge and experience are partial expressions. As evidence to support this view, the book draws richly upon the scriptures of the world religions and the insights of philosophers and mystics, Greek, medieval and modern, Eastern and Western. Yet it has a somewhat different flavor and perspective from other books on the unitive experience, such as Huxley's *Perennial Philosophy*, because the author has had a scientific education and has devoted her life to botanical research. Although the materials of science are not strongly in evidence, its basic concepts are never ignored or neglected.

The Manifold and the One is a beautifully conceived and executed effort to lead the reader to the sources from which he can draw his own evidence for unity. The problem of individuality, the important relationship between the essential and unique self-expression of every thing and the larger Reality in which it participates, is finely drawn. "Each thing represents one aspect of Reality, but Reality is itself wholly outside measurement; . . . The quality, for example, of any ani-

mal or plant may approximate to perfection *in its own kind;* but these perfections do not lead on to one another and they cannot be ranged along a scale. Each is ultimate in the sense of being an expression of the Absolute conditioned by the characteristics and limitations of a finite individuality."

From a consideration of the relationship of the one and the many, the author proceeds inevitably to the question of how a synthesis may be won—for such a fusion of the individual self with the whole is the unconscious state of lower organisms, and the conscious goal of awakened man. The obstacles which separate us from such unity are stated in many ways: as the division between reason and emotion, between the literal and the symbolic, between enlightenment and intellection, between mysticism and "no-knowledge," between thesis and antithesis, between mind and and body.

In her discussion of synthesis, Mrs. Arber says (p. 96), "On the view that there is a Unitary Whole, it may be assumed that if any subsidiary postulate is valid it is because it is one manifestation of the hypothetical whole. Such a subsidiary postulate can never be more than a partial truth, since it is bounded by the limitations of man's mind." Attempts at a synthesis of partial truths in order to achieve a larger view of reality may run us into trouble, if the systems which are conjoined are based upon different postulates. Then the result is merely an uneasy truce, shakily established through arbitration of opinion, rather than a genuine fusion. But if the postulates are truly of the valid sort, that is, primarily mind-born principles which have been structured and tested, then a genuine integration may result.

To achieve this end, Mrs. Arber makes a recommendation: "If any integrated synthesis is to be reached it must be by leaving the postulates free to develop, and through spontaneous growth to form organic connections linking them into a third conception more advanced and inclusive than either of them singly." From the evolutionist's point of view, this method may be the safest, but to one impatient for the beginnings of a genuine synthesis within this generation's lifetime it seems a trifle *dolce far niente.* It may even be impossible. For man is always intervening in this situation, since ideas are his province. Historically, postulates have seldom been left free to prove themselves in the long run or to wither away at the root. There have always been champions and true believers ready to infuse the dying notion with false life, and thus give it a continued existence beyond real usefulness. Every field of thought, one ventures to say, is crowded with such decaying postulates.

Thus if men have helped anachronisms to survive, they can equally help new and more valid concepts to take stronger root in contemporary thought. It takes no special insight to see that this is the great need of our world, whose complexity demands an integration if specialized knowledge (the partial view) is to be meaningful in relation to a world view (representing the whole).

Mrs. Arber never lets the reader forget this perspective. And she returns, finally, to the idea that man can, by his very awareness of the existence of a situation, begin to understand it. While we believed firmly that the universe was composed of nothing but small bits of discrete matter, there was little hope of relating man to his environment in any valid way. But now that we see things differently, the task is a possible one. That a final realization of unity must be a matter of experience, not of thought, may seem to put it out of the reach of knowledge, yet today scientists acknowledge the existence of the observer-effect which the experimenter has upon the experiment, which suggests that even in this most impersonal of man's endeavors he can recognize his real, if as yet mysterious, participation. The meaning of the basic belief in unity which this participation helps to confirm is put by Mrs. Arber in the category of a "mystery" which cannot be solved by rational-discursive thought alone. The question which is always asked, then (and never can be completely answered), is, why bother? To this Mrs. Arber offers the reply that a primitive and undeveloped conviction is always open to enrichment. If total enlightenment is denied to most of us, we may yet win a "glimmering torch, able to irradiate, though dimly, the fringes of the mystery." And this mystery, like all others, is something which is not secret, because deliberately hidden from us, but only elusive because beyond the reaches of analytical thought.

—E. B. Sellon

The Paramount Issue Surveyed

THE title of this work by Oliver L. Reiser is to be taken in a special sense: *The Integration of Knowledge* (Porter Sargent, Boston, 1958, 465 pp., index, $8). The author is Professor of Philosophy, and Chairman of the Department, University of Pittsburgh. He has, therefore, monitored for many years the principal topics debated among professional philosophers; he has watched the recent transformation of natural philosophy; and he has not feared to seek counsel from among people not qualified as academic or scientific philosophers. His aim is to review all of this aggregate, and to arbitrate the issues presented.

Such a procedure has an obvious advantage. The reader may be confident of being alerted to a great range of issues, some of which he, if an innocent bystander, might have overlooked. In this respect the book has very high value, indeed, and the large audience Professor Reiser commands will not be disappointed. But there is also an obvious risk of almost certain failure implicit in the procedure chosen: mere considerations of space alone ensure such a short exposition of critically important points as to make it almost certain that some of the innumerable issues must be slighted.

The author is aware of this danger, and his solution seems to be to make cross-references so as to compensate for deficiencies of exposition from over-compression in one place by leading the reader to the same topic in different context on another page. This is possible chiefly through the index. The solution is not altogether successful, the reader having the uneasy feeling that the author is setting out single-handed to arbitrate issues and assemble data which by sheer number and age-old refractoriness have compelled others to retire in defeat. A clearly defined methodology adequate to the purpose, stated (say in at least the second chapter, "The Unification of Knowledge") would have cleared the ground. On page 45 he explicitly mentions, only to put aside, Northrop's penetration to the start-

ing point in *The Logic of the Sciences and the Humanities.*

This volume is a remarkable virtuoso performance, and it serves to notice and to review within two covers the chief issues, the principal personages, and the stubborn problems that have been before us for decades. Except for the present high value we must put upon Indian thought, the volume is comprehensive and it aims at fundamentals. It applies logic to logic, humanism to the humanities, science to the sciences, and social thought to society. But since the integrator in the last analysis is the author—and no one man can bring off integration—the book cannot and does not convince the reviewer that this is all that needs to be done. In this, I feel certain, Dr. Reiser will agree. Meantime thousands of readers will be stimulated, be helped and be grateful, and Professor Reiser will have the personal satisfaction that comes from keeping the greatest of *all* issues alive, before a multitude of readers.

—F. L. Kunz

The Inner Nature of Man

AN attempt to bring man closer to his inner resources, and to put subjective experiences of a religious nature upon sound scientific footing is made in Dr. Carl G. Jung's new book, *Psychology and Religion: West and East* (Bollingen Series XX, Pantheon Books, Inc., New York, N. Y.; 1958, cloth, 690 pages; $6.00). This book is not to be confused with an earlier work with a similar, but shorter, title, *Psychology and Religion.* While this new publication contains a revision of the earlier manuscript, it contains in addition numerous related articles. For those interested in the relationship between the unconscious mind, the superconscious, and religious experience, the first section on "Psychology and Religion" is highly recommended. There are sections dealing with psychotherapy and religion, and with Jung's viewpoint on eastern religions.

Dr. Jung is to be thanked for bringing the subject of religion and religious experience out of the realm of the mysterious and for dealing with it in practical and theoretical terms that can give a sound basis to religious inquiry regardless of individual creed. He does not use the term "religion" to mean a creed, but says that "the psychologist, inasmuch as he assumes a scientific attitude, has to disregard the claim of every creed to be the unique and eternal truth. He must keep his eye on the human side of the religious problem, in that he is concerned with the original religious experience quite apart from what the creeds have made of it."

In bringing rationality to religious experience, he goes into some detail regarding the nature of the unconscious mind. Many authors assume the unconscious mind to be a repository of unpleasant and traumatic experiences, asocial impulses, and "bad" wishes which the individual does not want to enter consciousness or to be part of himself. Dr. Jung, on the other hand, emphasizes that the unconscious also contains resources and potentialities not realized by the individual, possibilities for better integration within the personality, untapped creativity, intuitions, and deep or profound experiences which might be termed religious. The unconscious also contains the superconscious. It may sound strange to include the two in this way, but the superconscious is capable of acting outside of awareness, and therefore is unconscious to the individual.

In another section, while discussing intuition, he says, "My psychological experience has shown time and again that certain contents issue from a psyche more complete than consciousness. They often contain superior analysis or insight or knowledge which consciousness has not been able to produce. We have a suitable word for such occurrences—intuition. . . . Most people . . . never take into account the fact that you do not *make* an intuition. On the contrary it always comes to you; you *have* a hunch, it has produced itself and you only catch it if you are clever and quick enough."

During a successful analysis, there is a shift in the individual from the conscious mind to a point between the conscious and the unconscious. This new point he calls the "self" and he considers it superordinate to previous functions. It allows the individual to have more easy access to the creativity of the unconscious. Dr. Jung stresses the importance of the totality of man, and the "self" allows more integration and thus more access to parts of the psyche which previously were outside of awareness.

In the dreams of his patients, certain symbols (particularly mandalas) refer to a new integration within the individual, or a deep experience, and sometimes to the "God within" and the establishment of a new center within the individual. He considers the belief that deity is only *outside* of man to be a prejudice mainly of Christianity. Other religions "insist, as do certain Christian mystics, upon the essential identity of God and man, either in the form of an a priori identity, or of a goal to be attained by certain practices or initiations, as we know them, for instance, from the metamorphoses of Apuleius, not to speak of certain yoga methods."

"We might, therefore, conclude that the symbol, spontaneously produced in the dreams of modern people, means the same thing as in olden days—*the God within.* Although the majority of cases do not recognize this analogy, the interpretation might nevertheless be true. If we take into consideration the fact that the idea of God is an "unscientific" hypothesis, we can easily explain why people have forgotten to think along such lines. And even if they cherish a certain belief in God they would be deterred from the idea of God within by their religious education, which always depreciated this idea as 'mystical.' Yet it is precisely this 'mystical' idea which is enforced by the natural tendencies of the unconscious mind. I myself, as well as my colleagues, have seen so many cases developing the same kind of symbolism that we cannot doubt its existence any longer."

Perhaps Dr. Jung does not present laboratory proof of the kind rigid scientific experiment demands, but he does approach the subject with a rationality and impartiality which is rarely encountered in this area of study. He makes the attempt to bring religious experience and the integration of self out of the realm of the mysterious into the practicality of everyday life. After all, we have not yet been able to subject the creativity of a Beethoven, an Einstein or a Rembrandt to laboratory scrutiny, wherein experiments are supposed to be subject to replication. Would creativity cease to be creative if it were replicated? This type of investigation has only just begun to be undertaken with enthusiasm.

—W. M. Nicholson